Carsten Vieland, DJ 4 GC

50 Ω Wideband Detectors

Following a discussion about various measurement techniques and diode types, this article gives a description of a broadband detector and a logarithmic indicator amplifier (fig. 1).

Fig. 1: A dBm-meter with a 70 dB indicator dynamic range (scaled for low-barrier diodes)

1. MEASUREMENT TECHNIQUES

In high-frequency technology, there is a recurrent demand for signals to be registered in terms of their amplitudes. This is the case in every swept measurement which is used with a normalized impedance (invariably 50 Ω) receiver (detector): the latter exhibiting no amplitude variations with frequency of its own. The difficulty in meeting adequate specifications increases sharply with increased sensitivity requirements, such as that presented by the assessment of return loss, by means of a wideband directional coupler. Although often, a relative indication will suffice (e.g. tuning for maximum); the power detector, or voltage detector, should satisfy the following demands: —

1) Voltage or power displayed accurately over a wide frequency range.
2) Good matching to the 50 Ω measurement system over a wide frequency range.
3) High measurement dynamic range together with an accurate as possible display over a wide range of input levels.
4) High basic sensitivity
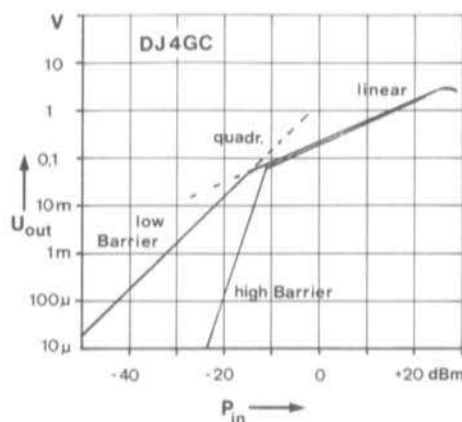5) High transit response for the measurement system in order that it may be used in a swept system.

Fig. 2: Idealized characteristic of a Schottky diode

range and accuracy, a few criteria ahould be observed: —

1) The employment of a diode which has the most favourable high-frequency specifications.

2) The installation of this diode in a suitable detector circuit.

3) The employment of DC processing circuits which have high dynamic range, a very low intrinsic drift and equipped with an exact indicator.

2.
FACTORS IN THE CHOICE OF THE DETECTOR DIODE

The rectification of high-frequency signals for measurement purposes may be undertaken by a variety of diodes. They are listed as follows: —

1) Germanium diodes (AA...)
2) High-barrier Schottky diodes (HP 2800)
3) Low-barrier Schottky diodes
4) Silicon point-contact diodes (1 N 23)
5) Planar-silicon diodes (1 N 4148)
6) Gallium-arsenide diodes (MFG 3000)

For each and every type of diode (**fig. 2**) there are many variants in relationship to the working frequency, the form of packaging (**fig. 3**), and other factors affecting both availability and price. If the exactly specified diode simply does not exist, the leading characteristics can be reviewed in order to arrive at a suitable choice for the particular application.

2.1. Germanium Diodes

The sometimes lowly-regarded germanium diode invariably displays, up to about 500 MHz, an optimal characteristic. The internal resistance of the germanium diode, which is important for matching purposes, is less dependent upon frequency than other types of diodes. The limit of detection lies under − 50 dBm (10 nanowatt) in a 50 Ωsystem. Now that this type of diode can be purchased by the kilo, it represents a very good choice right up to the 70 cm band.
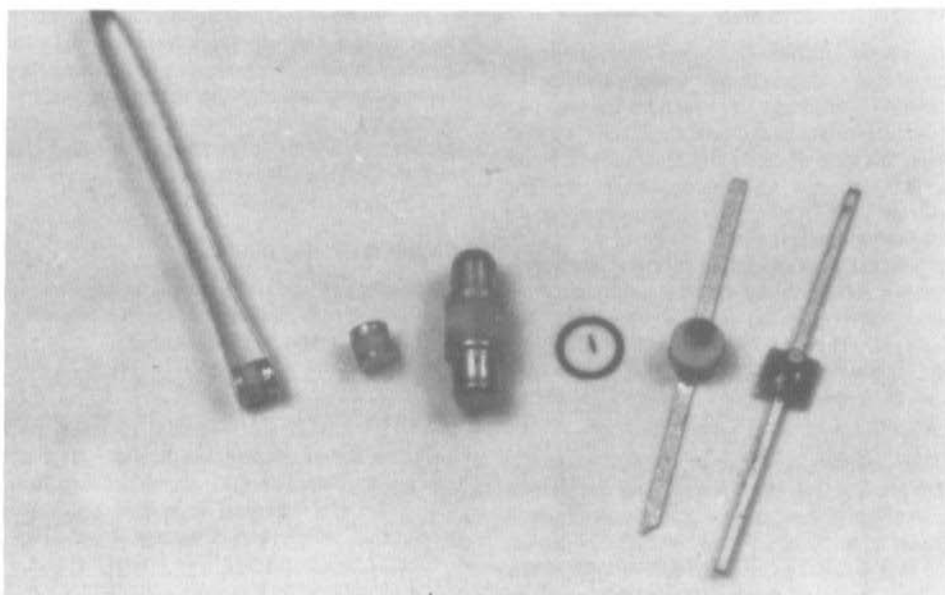
Between the requirements of 1) and 2), there is a certain common ground because an exact display is not possible in the absence of a good 50 Ω match. On the other hand, however, even with a good match, the absolute accuracy, under amateur construction limitations, is very much open to question. The requirements of 1) and 2), and with reservations 3), are easier to fulfil with a diode detector than with a thermal head. The high transit response requirement of 5) can only be accomplished thermally using highly demanding evaporation plating techniques (at threshold levels of approx. − 50 dBm). This demand is met, almost always, by the employment of a diode detecting head in self-made sweeper equipment.

The diode detector is very simple to effect when the demands upon a high absolute accuracy (i.e. relative indication), are not too great. Using careful constructional methods, a good basic accuracy and a high measurement dynamic range can be achieved. Some manufacturers have concentrated on this technique for their commercial wattmeters, e.g. HP: sensitive wideband milli wattmeter, Bird: wattmeter with changeable directional heads, and SSB-Elektronik: frequency-compensated power meter.

In order to achieve an even greater frequency range without sacrificing measurement dynamic

Fig. 3: Microwave diode forms from left to right:

1. BAT 14-094   Siemens (with connecting leads)
2. BAT 14-093   Siemens (pill-box form)
3. MA 40203   M/A-Conn. (small cartridge)
4. HP 5082-2778   (beam-lead housing)
5. MGF 3000   Mitsubishi
6. DDB 6783   Alpha Industries

Note: The beam lead-diode ring has a diameter of 2 mm

At higher frequencies, the rectification properties gradually diminish, and despite the impedance remaining constant, sets a system limit.

2.2. Schottky Diodes

Schottky diodes in glass packaging display no marked tendency to lose their rectification characteristics at high frequency in the same way that germanium diodes do. They are still rectifying efficiently at 23 cm. The series impedance (2), however, is low and very strongly dependent upon frequency. The impedance is very frequently under 50 Ω at frequencies around 1000 MHz.

The residual inductance, working in conjunction with the barrier capacitance, causes a discontinuity in the impedance at high frequencies. This effect is common to all rectifiers and makes the measured value very inexact at high frequencies. In general, a step-up transformation is effected, which makes the detected voltage many times higher.

In addition, the voltage current characteristic of high-barrier diodes is very unfavourable. Although the so-called barrier voltage is similar to that of the germanium diode at approx. 0.3 V, the V-I-characteristic exhibits a much sharper transition, making it unsuitable for use at very low signal levels. The lower limit of detection for high-frequency signals in a measurement system, without a bias current, is in the order of − 20 to − 30 dBm in a 50 Ω system.

2.3. Low-Barrier Diodes

Low-barrier diodes (zero-bias-diodes) exhibit favourable voltage-current characteristics. The low-level threshold for high-frequency performance is extended down to − 50 or − 60 dBm using this type of diode in a 50 Ω measurement system. In order to compensate for the germanium diode's inherently good properties, the low-barrier has to resort to special constructional techniques. A whole range of favourably-priced, **low-barrier Schottky diodes** encapsulated in glass, have appeared on the market in the past few years. They are mainly intended as a substitute for germanium diodes (e.g. BAT 42, BAT 43 from CFS, the VALVO BAT 86 or the TOSHIBA 1 SS 99).

There are also low-inductive and low-capacitive microwave forms, having small dimensions, in the form of cartridges, pills or beam-lead housings. These types, however, are decidedly expensive (30 to 300 DM) but they do represent the almost optimal detector diode. This is the type that commercial manufacturers of wideband detector heads employ.

2.4. Silicon Point-Contact Diodes

At first sight, all the problems of the favourably-priced point-contact diodes, such as the 1N21, 1N23, 1N78, 1N26 etc, seem able to be remedied at one fell swoop. The low-barrier characteristic is associated with very favourable high-frequency characteristics. A more exacting study of the technical data reveals, however, an unsurmountable problem. It concerns those diodes possessing internal LC compensation and thereby having a relatively narrow range of frequencies. They are so constructed that their incorporation into a proprietary microwave waveguide is easily carried out. The semiconductor crystal is located in an optimum position in the high-frequency field in order to effect a suitable match. In a waveguide detector, these silicon point-contact diodes display good characteristics although the input VSWR can only be optimized over a 10 % frequency range. For coaxial wideband measurement, however, their large dimensions make them entirely unsuitable. Owing to the differing impedance relationship to the

mandatory 50 Ω system impedance, this type of diode is about 20 dB more sensitive than its coaxial relatives. The lower threshold limit of an X-band waveguide detector using an 1N23 is astounding − 70 dBm. Saturation effects occur at quite a low level. At 0 dBm the rectified DC no longer follows the increase in HF input power.

2.5. Silicon-Planar Diodes

Silicon-planar diodes for small signal applications have so many disadvantages for detector work that they will not be considered at all.

2.6. GaAs Diodes

Gallium-arsenide diodes are suitable for high levels and therefore find applications in low-intermodulation mixers at up to very high radio frequencies. As the barrier voltage is quite high (about 0.75 V), and well above that of the silicon diode, its application in a universal detector is not favourable as the result table indicates.

3.
THE CONSTRUCTION OF A BROADBAND DETECTOR PROBE

The general experience in the dealings with microwave components seems to favour construction in a stripline technique with as little disturbance from stray inductance and capacitance as possible. On account of the very small current angle-of-flow, series inductance can be very disruptive (step-up transformation). For HF, VHF and UHF bands a printed circuit board was tried out which has already proved itself in attenuator pad construction. The mechanical construction details conform to those detailed in (6). A teflon board (RT-DUROID 5870) with an SMA plug (threaded, flanged plug) is used. The board housing can, of course, be tailored according to ones own mechanical possibilities.

The decoupling of the "cold" end of the diode requires a particularly lossless and low-inductive
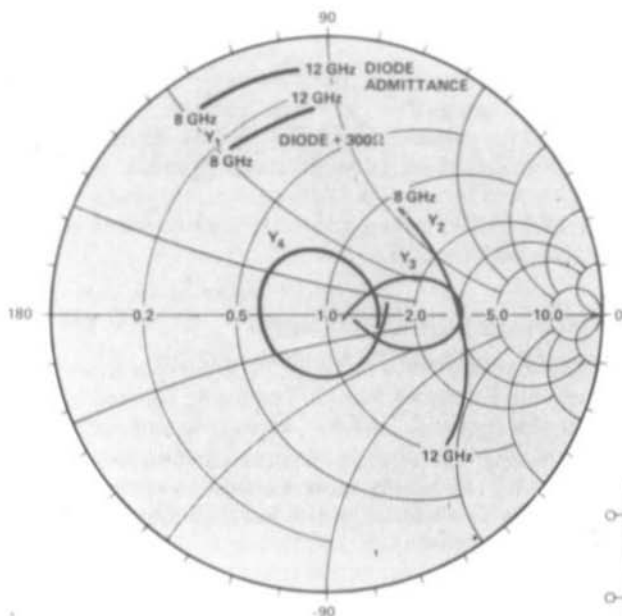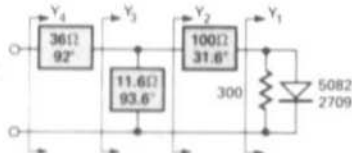
Fig. 4:
An example of the matching
of a detector diode with the aid
of a transformation line (from
HP application note)

filter. Normal disc and above all SMD capacitors are frequently not suitable as the whole spectrum, including harmonics produced in the process of rectification, should be provided with the same ground potential. The Fourier analysis of a half-wave rectifier output, reveals an unending series of harmonics of the input signal. If the basic frequency lies in the GHz region, the filter requirements must be effective right to the highest amateur band. Even an input at 500 MHz to a rectifier with a high-grade filter capacitor, has been observed to produce harmonics as high as 20 GHz — using a very expensive spectrum analyzer for the evaluation, of course!

As disc capacitors are not normally specified at high frequency with tan δ, the constructor must use a certain amount of intuition in order to search a suitable one out. In the author's experience, capacitors with a small capacity, of smallest thickness and a light dielectric, seem to fit the bill. High-quality chip capacitors (e.g. from ATC) can also be employed. The capacitor is so laid in the board that the copper removed by the drill can be replaced over it by thin sheet copper.

Unfortunately, however, the ever-decreasing diode impedance with frequency (even with high-grade microwave diodes) precludes a truly wide-band match without resort to some special measures. For the diode used here, chip resistors and capacitors did not yield the author the kind of root-locus that he was seeking. An HP application, however, suggested a solution. Using a computer, the matching in the entire X-band (8 to 12.4 GHz) was accomplished by selective transformer-line optimization. This measure resulted in a 4 dB gain in sensitivity, as a bonus. Outside the working frequency of the device, this form of compensation crashed. The design aim of a working spectrum extending into the X-band regions from the short-waves, was not realized by an optimized transformer circuit but by an experimentally optimized, wideband, match similar to that used in a diplexer (fig. 4).

In order that the total series impedance is not determined solely by that of the diode, a 27 Ω series resistor, in chip form, is included in the measurement head. This series circuit displays, according to the diode employed, a very good
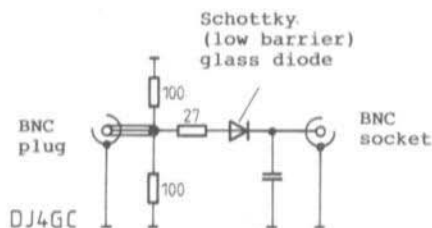
Fig. 5a: Detector circuit for diodes having glass encapsulation

Fig. 5b: SHF detector circuit diagram

match across the band, 3 to 5 GHz, even without other circuit refinements. The series resistor also dampens resonant effects in the diode and also the effects of the step-up transformation due to the stray LC components. The dependence of the detector head's output voltage with frequency is therefore reduced.

In the interests of a 50 Ω input resistance, even at low frequencies, the present circuit contains a parallel resistance to earth (**fig. 5a**) which is countered by the effects of stray series inductance at high frequency (**fig. 5b**), that is, a part of an RL low-pass circuit. In a practical circuit, this inductance is formed by the lead wire to the chip resistor.

The soldered-board construction of this diplexer circuit has, due to this inductance, lost something of its functional elegance but does possess a good match and directional characteristics from
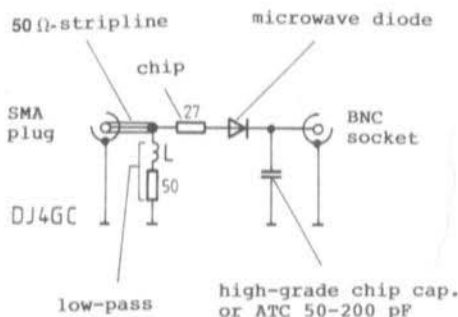
HF right into the X-band frequencies. This favourable result is obtained using a 2 to 6 mm length of 0.5 mm wire — length according to diode.

4.
MEASUREMENTS ON VARIOUS DIODE DETECTORS

Using a standard construction with a 3 mm long wire for the compensation inductance, many types of diodes were examined. As a screen presentation of the DC output voltage representing the return loss (indirectly the VSWR) over a trace width of 0 - 12 GHz surpasses the author's equipment capability, only representative bands in the total range have been given.

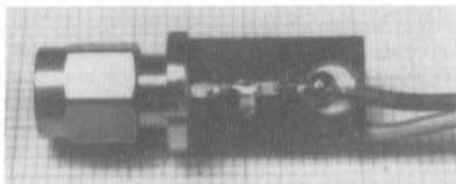Fig. 6: HP detector with APC 3.5 plug

Fig. 7: Stripline construction for SHF using diode DDB 6783 and SMA plug, PCB material 0.5 mm RT-Duroid
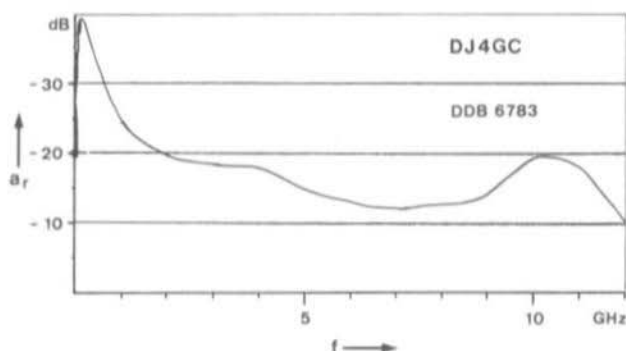
Fig. 8:
Return loss from 0 to 12 GHz

The reference detector used in this survey was the HP 33330 B (**fig. 6**) for which the manufacturers specify a detected output voltage constancy over the 10 MHz to 12.4 GHz of $\pm$ 0.3 dB and 12.4 GHz to 18 GHz, $\pm$ 0.6 dB. The VSWR up to 8 GHz is better than 1.2 and from 8 to 18 GHz the VSWR does not exceed 1.5.

This kind of phenomenally-small, ripple specification in both input VSWR and output voltage is only achievable with computer optimized and miniaturized deposition techniques and is far removed from the soldering-iron techniques open to the amateur. But despite these limitations, reasonable results can be achieved even with the simple equipment to hand. A home-constructed detector using the diode DDB 6783 (**fig. 7**) by Alpha-Industries had an output ripple of $\pm$ 1 dB up to 12 GHz relative to that of the highly expensive Hewlett Packard head (**fig. 8**), but with a somewhat higher output voltage.

At 12 GHz, the testing had to be curtailed owing to the lack of a suitable sweep generator. There was, however, a return-loss of less than 10 dB (VSWR 2 : 1) at this frequency – within the borders of serious measurement accuracy. The relatively small filter capacity of 50 to 200 pF determined the lower frequency limit at approx. 100 kHz.

The detector shown in **fig. 9** has a low-barrier diode MA 40202 and possesses a still higher sensitivity, well into the X-band, but due to its larger diode geometry, displays a somewhat larger ripple over the spectrum for both detected output and matching.
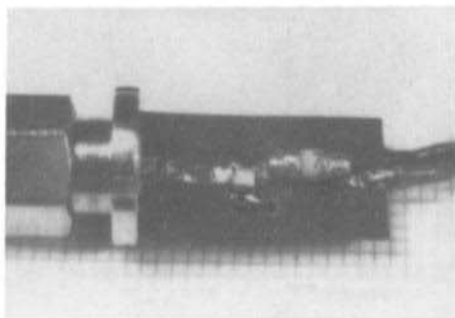

Fig. 9:
Circuit as in fig. 7 but with ATC filter capacitor under the diode housed in a small cartridge
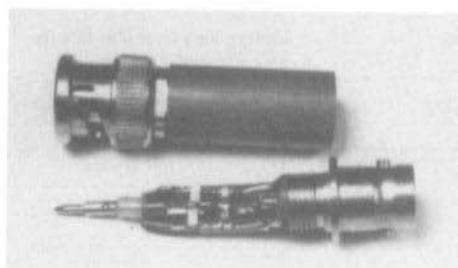
Fig. 10: Stripline construction to 2 GHz approx. for BNC connector

Fig. 11: The series inductor to the 50 Ω resistor is shown here

The BNC detector (for diodes having glass encapsulation, **fig. 10**) displays a practically constant output voltage extending from short-waves right up to 1.3 GHz. The characteristic then gradually rises by 2 dB at 2.3 GHz under the combined influence of the series inductance R_v and the diode. A similar characteristic is also apparent with the diode 1 SS 99 as regards the output voltage and input VSWR but the sensitivity, and thereby the dynamic range, is some 20 dB better.

Not all the diodes examined here are commonly available in every corner shop. The basic constructional details of **figs 11, 12 and 13** may be regarded as typical. In the search for a suitable semiconductor, properties such as: small form, high-limit frequency, low-barrier characteristic, price and availability are the deciding factors. An unknown flea-market type diode, implanted into a standard-constructed detector head, will nearly always produce results not too far short of the best available. The traces of **figures 14, 15, 16 and 17** show representative test results.
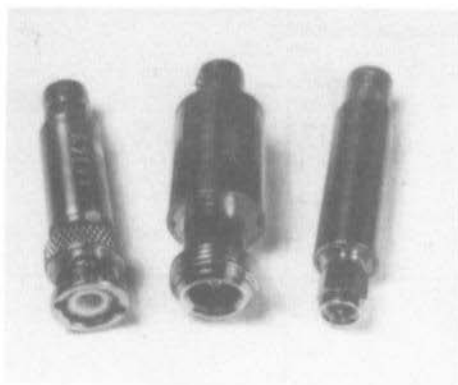

Fig. 12: Amateur-constructed detectors in three forms of construction. The housing with the SMA plug contains the circuit of fig. 7
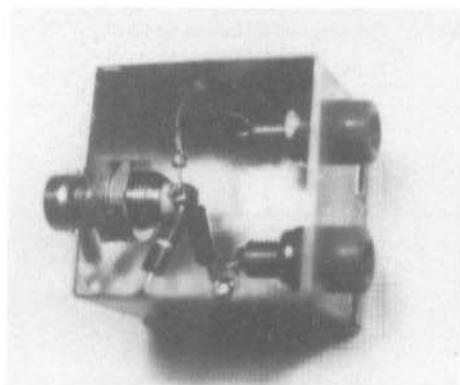

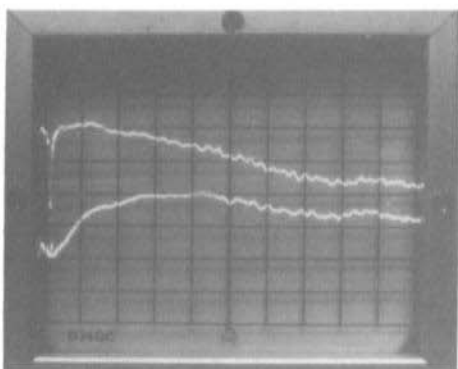Fig. 13: This is also admissible — up to about 500 MHz!

Fig. 14: Return loss of a circuit as in fig. 10 using
diode BA 481 (Valvo) from 0 - 2 GHz
h: 200 MHz/box
v: 10 dB/box
Note: The reference line (upper) indicates
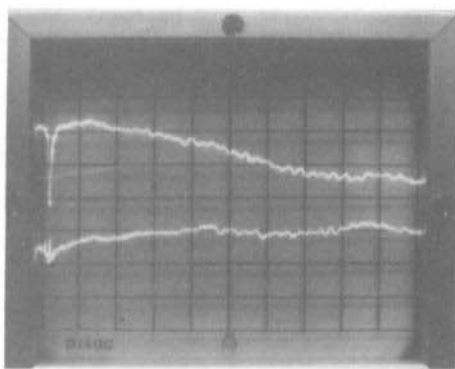0 dB return loss

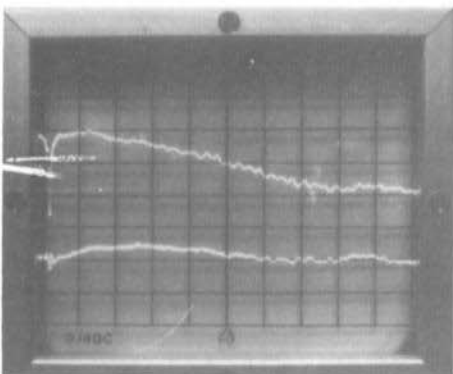Fig. 15: Same circuit as in fig. 14 but with a 27 Ω
diode series resistor

Fig. 16: Return loss of the SHF detector of fig. 7
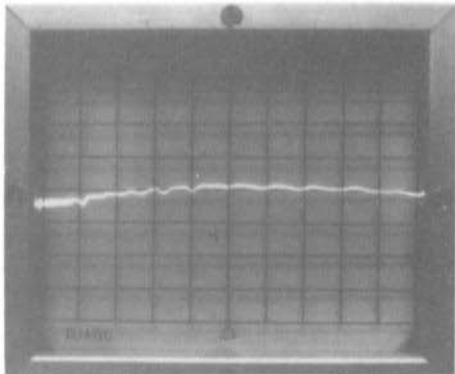(SHF detector)

Fig. 17: Detected output of a BWO signal from 8 to
12 GHz using the detector of fig. 7
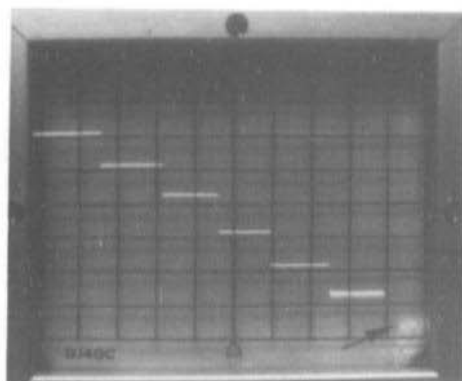h: 400 MHz/box (approx.)
v: 10 dB/box

Fig. 18: The stepped attenuation of an HF signal in 10 dB steps to − 60 dB in a log-linear presentation. The lowest level is contaminated by noise (arrow)
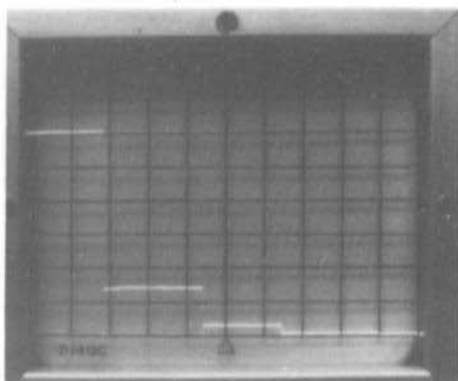

Fig. 19: The same range of attenuation using a linear system. The measurement range can be clearly seen to be several orders smaller

5.
LOGARITHMIC DISPLAY AMPLIFIER

The detected output (voltage) of a diode detector, represents the measure of the high-frequency input signal. In the simplest form, a suitable indicator could be a voltmeter with a calibrated scale but only a very limited dynamic range would be available. The low-level region can only be readily detected with the aid of a low-drift DC amplifier. This must be capable of accepting input voltages of between about 1 μV and 5 V and handling them in exactly the same manner. Detector heads with low-barrier diodes can handle inputs with a range of 70 dB (figs. 18 and 19).

The author has developed a circuit which displays this high dynamic range linearly on a meter-scale (fig. 20). The heart of this unit is a logarithmic, operational amplifier, the output of which is proportional to the logarithm of its input. For circuit technical reasons, this analogue computer circuit is changed into a current converter as this type of circuit has a higher dynamic range with current drive (fig. 21). The input to this voltage/current converter may be reversed in polarity by means of the DPDT switch at its input. The log. amplifier's output voltage lies between − 7 V and + 2 V and must be offset to be referenced to ground potential.

An unfortunate trick of nature has given detector diodes a characteristic knee at about the − 20 dBm input level. Under this power, the input
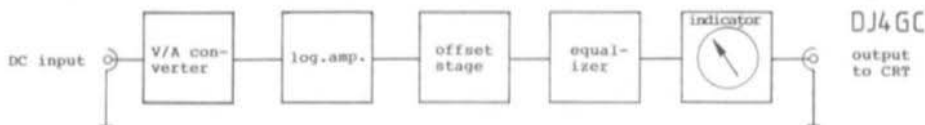

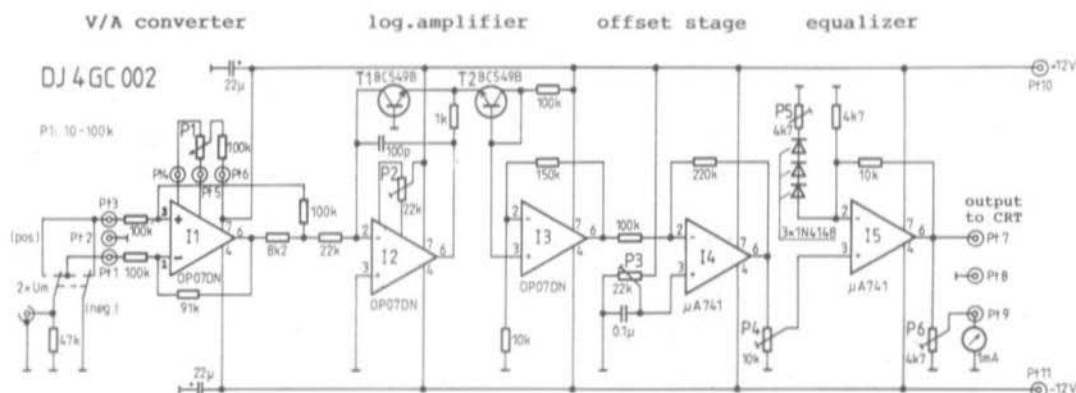Fig. 20: Measurement amplifier block diagram

Fig. 21: Detailed circuit schematic of measurement amplifier

level is power-linear and above about 0 dBm a linear rectified voltage output is generated. In the transition region there is, of course, a mixture of both. This knee in the characteristics can, however, be largely compensated by the final equalizer stage.

As this circuit is intended to have a universal application, it was designed to work with various diodes of differing types and circuit dispositions and therefore the unit has been provided with the necessary means of adjustment to cope with this variety.

The operational amplifiers used in the first two stages are extremely low-noise and low-drift types such as the OPØ7, or better the OP77. Experiments with the integrated log. operational amplifier, Intersil ICL 8048, despite its high price, did not deliver the same good results as one made from discrete components. Although, at low levels, the operational frequency limit of the log. amplifier sharply decreases, it is still fast enough to fulfil the highest demands of sweep frequency measurement. At the threshold of detectability (under − 50 dBm), the few microvolts of DC signal
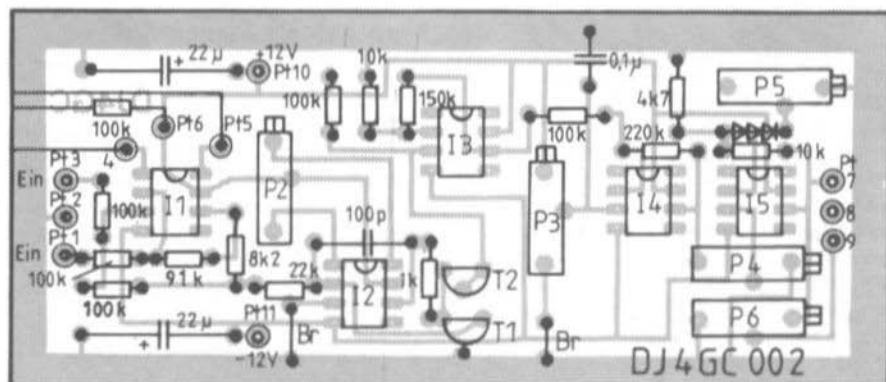

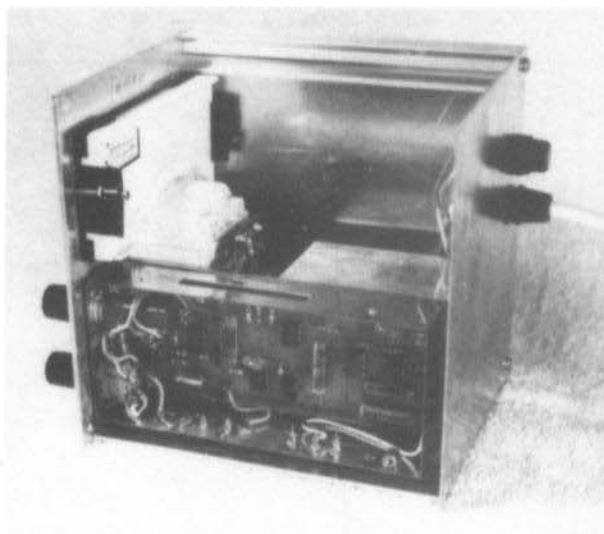Fig. 22: Component layout plan of the PCB DJ 4 GC 002

Fig. 23:
In the completed instrument, the cover has been removed to show the board. The small power supply unit is located behind it in a second tin-plate box

are overwhelmed by the thermal noise and residual hum. The output indicator then displays a certain nervous behaviour which disappears completely when the input is raised just 10 dB. This threshold noise limit may be seen in **fig. 18** at an attenuation of 60 dB. To compensate long-term temperature variations and thermal voltages generated in input connections, the offset adjustment of the first stage has been made variable from the front panel in order that the basic noise lies on the moving-coil indicator at − 53 dBm (approx.).

As commercial diode detector heads frequently have a negative output voltage, the voltage/current converter's input is fitted with a DPDT switch to accommodate this. This switch should be of the highest quality in order to avoid thermal voltages being generated at the contacts, voltages which can be as high as the input signal when working at low levels. The influence of temperature on the two low-noise transistors (e.g. BC 549 B or BC 550 B) is opposing and therefore to a large extent cancelling. It is advisable to bind these two transistors together with a metal band to make them thermally as one − they are deliberately located by each other for this purpose.

The printed circuit board of **fig. 22** is 116 x 48 mm, single-sided and designated DJ 4 GC 002. It is fitted into a tin-plate box together with a 10-turn potentiometer for the offset voltage adjustment and the polarity change-over switch (**fig. 23**). The box is totally sealed against the ingress of external electrical fields.

6.
ADJUSTMENT OF THE MEASUREMENT AMPLIFIER

The multitude of adjustment points designed into the measurement amplifier will probably cause a few misgivings about the realization of the project. By a methodical and accurate adjustment, together with an exact adherence to the following procedure, an accuracy of ± 1 dB may be attained throughout the whole of the 70 dB dynamic range.

The following test equipment is required:

1) A signal source of exactly 100 mW (+ 20 dBm) with an adjustable output. For example, a

handheld Tx/Rx set to "low power" and with a variable power supply.

2) A 0 - 70 dB attenuator, switchable in 10 dB steps. Fixed pads of 10, 20 and 40 dB are also usable but not so convenient.

The adjustment procedure is as follows:

1) Without an input signal, the front-panel potentiometer P1 is adjusted until the voltage to ground after the 8.2 kΩ resistor of the voltage/current converter is zero.

2) The point at which the voltage has been nulled in 1) i.e. the common of the 91 kΩ, 8.2 kΩ and 22 kΩ resistors, is then temporarily strapped to ground. Transistor T1 is then bridged with a 22 kΩ resistor. By means of I 2's offset trimmer P2 (22 kΩ), the output of I 2 is also brought to zero voltage. The strap and the 22 kΩ resistor are then removed and the logarithmic amplifier is ready for service. Its output voltage, for a 70 dB dynamic range, varies between − 5 V and + 1 V. '

3) The detector is then connected to the amplifier's input and a signal from the signal generator injected via the stepped attenuator. When the input signal to the detector is switched between − 20 dBm and − 50 dB, in 10 dB steps, the amplifier's output voltage should follow accordingly. If it does not, correct it with P1. Adjust trimmer P3 (22 kΩ) of the offset-stage such that its output is − 50 dBm when its input is zero voltage. This step ensures that the output of this stage is always positive with respect to ground.

Note: This applies to Schottky low-barrier or Germanium diodes. "Normal" Schottky diodes cannot achieve the lowest levels and the instrument scale must be calibrated accordingly.

4) Set the HF input level to − 10 dBm with the stepped attenuator and then adjust the multi-turn pot P4 such that a flow of current through the diode chain is just detectable. The voltage at the input of the last stage is then around 1.4 V. P4 determines the position of the compensating characteristic knee in the amplifier.

5) The diode chain, together with multi-turn potentiometer P5, corrects the voltage linearity characteristic of the detector diode in the "high-level" range. The trimmer is adjusted so that the rise in voltage at the output of the amplifier (i.e. the instrument) between 0 and + 10 dBm is exactly the same as that between, for example, − 30 dBm and − 20 dBm.

6) The multi-turn P6 for the instrument is adjusted so that the indicator calibration scale is in accordance with the input level.

7) The linearity and range of the indicator scale may also be optimised with controls P4, P5 and P6.

It must be admitted, that a simple equalizer such as this cannot be expected to match exactly every detector characteristic. The provision of four or five diodes in the compensating chain of the same low-barrier type that is used in the detector head, will normally yield a small improvement in the compensation. The inclusion of temperature compensation measures was also considered.

In more demanding applications, commercial instruments take the detector head output to an analog to digital converter. The digital output is then compared with a memory which holds information as to the exact characteristic of the detector head in use. Using high-speed converters, and very low access times for the memory, enable this approach to be used in a sweep frequency system. In order to ensure a high display accuracy, a new program is necessary each time the detector head is changed.

The application of a bias current to normal Schottky diodes for sensitivity enhancement, causes problems with temperature dependent offsets and thereby deformation of the amplified transfer characteristic. It is the author's experience that this measure, in spite of complex circuitry, is not as effective as the employment of low-barrier diodes.

7.
APPLICATIONS FOR THE HF DETECTOR HEAD

The wide frequency range, the good match and the high-dynamic range of the subject diode
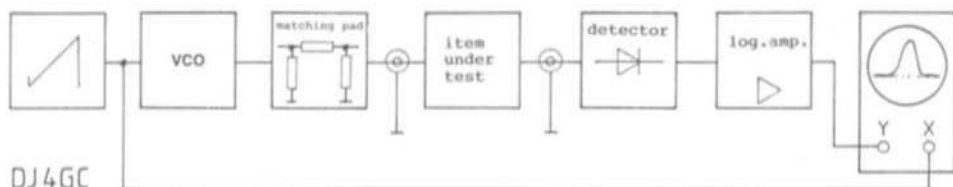
Fig. 24: The basic test set-up of a sweep measurement

detectors are favourable requirements for tuning work, for power and attenuation measurements as well as for applications in sweep techniques (**fig. 24**). The logarithmic indicator assists in the assessment of the test results. The cathode-ray tube used in the indicator oscilloscope should be of the long-persistence type. More practical still, is the employment of storage oscilloscopes which are making ever increasing inroads into the measurement scene. They will also allow a printed output of the displayed trace by means of a picture store output to a graphic printer.

The return loss is the quantity by which an impedance is adjudged to approach that of the system normalized impedance (mostly 50 Ω). This may be carried out using a wideband sweep test set-up in order to detect discontinuities caused by spurious resonances etc. (**fig. 25**). The directional coupler, or RF bridge, must possess a uniform coupling factor over the whole of the test frequency range.

The one described by DJ 7 VY in (7) has a constant coupling factor extending from the short-

wave band right up to the 13 cm band — if it has been carefully constructed (I constructed a longer version of this RF bridge and the return loss was better than − 30 dB over a frequency range of 100 kHz to 1000 MHz — a highly recommended item of precision test equipment for the amateur constructor − G3ISB). Hewlett Packard has produced a wideband coupler with a − 22 dB coupling factor, constant and with high directivity, over the frequency range 2 to 18 GHz!

A reference line is established before the test object is introduced, by either open-circuiting the test-object port or terminating it with a precision pad of known impedance. By this means, any frequency dependent errors in the RF bridge, or in the detector, may be eliminated. The displays of fig. 14, 15 and 16 were produced using this technique.

High-dynamic range measurements are dependent for their accuracy upon the spectral purity of the signal- or sweep-generator employed. Both harmonic and non-harmonically
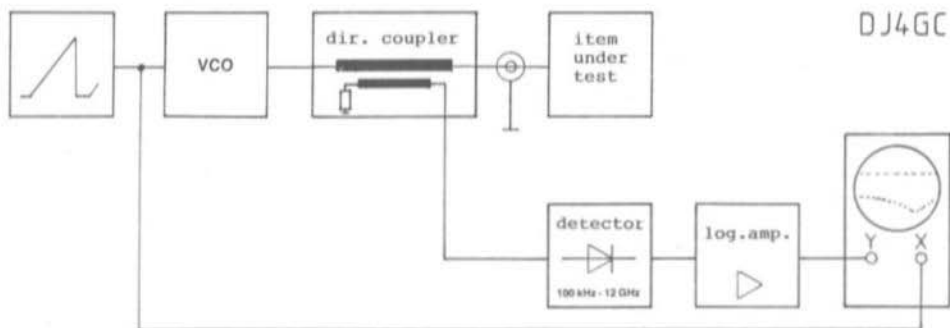

Fig. 25: The basic test set-up for a swept return-loss measurement

Diode	Manufacturer	Threshold	Type	Housing/ Limit frequency
AA 118	ITT	− 48 dBm	Germanium-Diode	Glass bead
AA 143	ITT	− 52 dBm	Germanium-Diode	to 500 MHz
HP 2900	HP	− 28 dBm	Schottky-Diode	Glass bead
BA 481	Valvo	− 31 dBm	Schottky-Diode	to 2 GHz
1 SS 99	Toshiba	− 55 dBm	Low-Barrier-Schottky-Diode	
MX 1435	Metelix	− 25 dBm	High-Barrier-Schottky-Diode	
BAT 14-093	Siemens	− 18 dBm	High-Barrier-Schottky-Diode	Miniature SHF-diode
DDB 6783	Alpha-Industries	− 40 dBm	Low-Barrier-Schottky-Diode	to 12 GHz
MA-40203	M/A-COM	− 55 dBm	Low-Barrier-Schottky-Diode	
MGF 3000	Mitsubishi	− 8 dBm (!)	Gallium-Arsenide-Diode	

Table 1: Measured threshold limits of detector diodes

related signals can easily present a very much worse measurement result than is actually the case. In particular, sweep-generators often have spurious output signals which are only − 20 dB with respect to the fundamental output. These harmonics must be kept out of the measurement system by means of low-pass filters when using wideband sweep techniques. The "exclusive" way to make a swept measurement is to use a spectrum analyzer with a tracking generator. The latter follows the received swept signal exactly over the whole of the measurement range. This technique allows measurements with a dynamic range of up to 100 dB.

Using a small Gunn oscillator, for example, the polar diagram of a directional antenna may be taken. This test set-up can be used for directional antennas of all frequencies and is characterized by the absence of measurement range-switching because of the high-dynamic range of the detector head.

In general, this technique is useful for all RF measurements involving voltage or power linear scales which require amplifier or attenuator-range switching. In particular, where range pads have to be inserted and removed, involving perhaps the use of connector adapters, the swept technique can avoid quite massive measurement errors.

8.
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